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DEPENDENT DATA STREAM TRANSMISSION PROCEDURE

The domain of the invention is that of data transmission in the form of one or several data streams, each composed by elementary stream units. More specifically, the invention relates to the optimisation
5 of the processing of these elementary stream units when the latter are dependent from, or related to, one or several other stream units.

When a signal, for example, a multimedia-type signal, is transmitted over a single channel in a
10 synchronous manner, the processing of a stream unit (arises few or no problems). The necessary data is received previously.

On the other hand, this is not the case in asynchronous systems that can implement several
15 transmission channels, and/or several servers - each transmitting a part of the desired signal. This is the case, for example, in the transmission or broadcasting over an IP-type network.

In this case, we may receive a stream unit that is supposed to complete others that have not been received. For example, this could be data enrichment information of a higher hierarchical level, in which the data is encoded using hierarchical encoding (a stream can therefore correspond to a given hierarchical level.) The processing of enrichment data will therefore give a random result, generally leading to significant degradation of a recovered signal, or even the complete blocking of the decoder.

The previous art in terms of multimedia synchronisation is essentially represented by RTP-based transport protocols and by MPEG-4 (Synchronisation Layer.) In the approach used, the synchronisation mechanisms have been mainly designed for temporally synchronising audio and video streams so that they may be presented without lags. This data is conveyed using a time stamping system (a reference clock, and decoding and presentation stamps.)

With the advent of hierarchical encoding, where various time and spatial enrichment levels are used to produce a presentable frame, the inventor has noted that a new need for synchronisation arises.

Indeed, streams must be synchronised before they are decoded (and not only during their presentation.) This constraint is more complex than presentation synchronisation because the units required for decoding the unit must be identified in order to produce a correct frame. A single lag can lead an entire stream as well as

all the streams that are based on it to be unusable. This is a new, not apparent, problem identified by the inventor.

5 A similar problem arises when a received stream unit must be decoded, or decrypted, using data (for example, a decoding key) that the terminal should have received, but has not received. Once again, the result of the decoding procedure will be, at least, inefficient, generally, harmful (in terms of recovered signal), and can lead to
10 the blocking of the terminal. In these two cases, an undesired and troublesome process would have been performed.

Another significant problem found in broadcasting (multicast or broadcast) systems is that the same data
15 has to be multibroadcasted to allow users connecting at any instance to receive all the stream(s) that they have selected. This specific aspect is already discussed in the request for patent EP-014600462, not yet published, in the name of the title holders of the present request
20 for patent. According to this technique, processing is performed at transport level, which forces a processing of each stream unit, taking into account the specificities of the various transport types.

The previous art in terms of multimedia
25 representation in broadcast and multicast scenarii is described in the specification of the "carousel MPEG-4. Nonetheless", therefore, a certain number of functions are prohibited or become high data rate consumers. In the two delivery scenarii considered, input points to the

multimedia presentation must be indicated at any time. This is translated into a repetition of data relative to the description of the scene: BIFS scene, textures.

5 Once the multimedia content becomes rich, this simple repetition is not unacceptable and leads to excessive downloading times. Furthermore, this specification does not allow broadcasting certain multimedia elements (short audio/video clips.)

10 In particular, the purpose of the invention is to overcome various inconveniences of the state of the art.

More specifically, an object of the invention is to provide a technique that permits to manage efficiently stream units when the latter depend on, or are related to, one or several other stream units.

15 Furthermore, an object of the invention is to provide such a technique, which allows the management of linked streams, in particular, in the case of data an encoded by hierarchical encoding or encoding that includes encoding that associates base data and
20 enrichment data.

Another object of the invention is to provide such a technique, which permits to optimise the transmission of multibroadcast scenarii, and in particular, to reduce the resource quantity used, without reducing the quality of
25 the reception.

The purpose of the invention, in other words, is to optimise the processing performed in the terminals, both in terms of quantity and quality.

These objectives, as well as others that will be

indicated below, are reached according to the invention using a transmission procedure of at least one data stream to at least one terminal, in which the stream(s) are organised into stream units. According to the invention, at least some of these stream units include at least one pointer that points to at least one stream unit of said stream or of another stream that may have been received previously in a terminal, called required previous unit, in order to avoid performing the processing of this stream unit within said terminal if the required previous unit(s) is(are) not received.

Thus, a logical synchronisation system is available, which permits an easier management of stream units, limiting the processing in terminals, to improve the resolution quality, etc.

The format of data thus defined, according to the invention, can also be implemented not only for the transmission and reception of streams, but also for their broadcast, their recording and their storage.

The invention is therefore based, in particular, on the identification of the new problem of "back" synchronisation of streams or stream units, and on the unapparent observation that the most efficient solution is not to process the stream units when not all the elements to do so are available. Indeed, it appears to be preferable, in terms of signal recovery, to ignore a stream unit rather than decoding it, which would lead to a degradation of the recovered signal, or even the blocking of the terminal.

As an advantage, the procedure of the invention includes the transmission of a least two data streams that are transmitted separately, one stream unit of an initial stream pointing to at least one required previous
5 unit of at least one second stream, in which said stream unit of the initial stream includes enrichment data of the data contained in said second stream(s.)

In this case, these data streams can advantageously correspond to different hierarchical levels of a
10 hierarchical encoding, in which the processing of a stream unit of a given hierarchical level is only done if the stream units of the corresponding lower hierarchical level(s) have been received.

This stream unit can point to at least one previous
15 unit, which defines a sequence of required previous units.

According to an advantageous characteristic of the invention, at least one of these pointers allows finding at least one required previous unit that includes data
20 that allows the decoding and/or decrypting of the considered stream unit.

Preferably, said required previous unit(s) include(s) data that allows a terminal to decide whether the data of a considered stream unit must be decoded
25 and/or decrypted, then displayed after decoding.

According to another advantageous implementation, at least one of these pointers points to data that can be known from said terminal, so that the terminal can decide on its capacity or incapacity to process the

corresponding stream unit.

Advantageously, according to another aspect of the invention, at least one of these stream units includes at least one pointer that points to at least one stream unit of said stream or another stream than can be received in the near future.

Preferably, this or these stream units that can be received in the near future have a marker that allows creating a link with said pointer(s.)

Thus, advantageously, the pointers of at least two similar stream units transmitted at distinct times can point to the same stream unit that may be received in the near future.

Preferably, the procedure of the invention implements an indicator that indicates the role of the pointer(s) from among at least two roles that belong to a group that includes:

- the designation of at least one previous stream unit that must be decoded to allow the taking into account of the considered stream unit.

- the designation of at least one previous stream unit that includes the required data to decode and/or decrypt the considered stream unit, and/or a reference to a protection system status.

- the designation of at least one subsequent stream unit.

Advantageously, at least some of these data streams include a dependency descriptor that defines this role.

Advantageously, at least some of these data streams

include a dependence marker, which allows its identification as a required previous unit and/or an identification marker of said stream unit in said stream.

Preferably, the procedure of the invention is
5 implemented at the synchronisation level, so that no preliminary processing of a received stream unit is necessary.

The invention also relates to one or several data streams transmitted according to the transmission
10 procedure described above. As mentioned, such a data format can be used for transmission, broadcasting, reception, and recording (for example, using a video recorder or optical disk recorder) and the storage of data (for example, on a CD-ROM, a tape, a remote server,
15 etc.)

Also note that the invention permits to combine easily several of these aspects. For example, some data streams can be broadcast, and others provided on CD-ROM, or through a server, in which the second ones must be
20 known in order to decode (or optimise) the first ones.

Such a data stream is organised into stream units that are transmitted independently from each other, in which at least some of these stream units include at least one pointer that points to at least one stream unit
25 of said stream or to another stream that may have been received previously in a terminal, called the necessary previous unit, so that processing of said stream unit is not performed in said terminal if the required previous unit has not been received.

The invention also relates to servers for data designed to be transmitted to at least one terminal in the form of at least one data stream organised into stream units that are transmitted independently from each other, in which at least some of these stream units include at least one pointer that points to at least one stream unit of said stream or to other streams that may have been previously received in a terminal, called the previous necessary unit.

10 The invention also relates to terminals that can receive at least one data stream organised into stream units transmitted independently from each other, in which some of these stream units include at least one pointer that points to at least one stream unit of said stream or
15 of another stream that may have previously been received in a terminal, called a previous necessary unit.

 The invention also relates to reception procedures of at least one data stream organised in stream units transmitted independently from each other, in which some
20 of these stream units include at least one pointer that points to at least one stream unit of said stream or of another stream that may have previously been received in a terminal, called a previous necessary unit, and the reception procedure includes the following stages:

- 25 - analysing said pointer(s) of a stream unit.
 - processing said stream unit if the said required previous unit(s) have been received.

 Lastly, the invention relates to the use of the transmission procedure, in particular, for one of the

applications belonging to the group that includes:

- systematic broadcasting of a message before accessing a program selected by the user.
- conditional access to a specific quality level and/or a specific option of a program.
- interactive television.

Other characteristics and advantages of the invention will become clearer upon reading the following description regarding a preferred embodiment of the invention, given as an illustrative example, and the attached figures, among which:

- Figure 1 illustrates the principle of the dependence management of a data stream with respect to another, according to the invention.
- Figure 2 presents an implementation of the invention, in the case of the broadcasting of a stream (broadcast) and its reception by two terminals, in the form of time-staggered sessions.
- Figure 3 illustrates the case of a synchronisation linked to the decoding or decrypting of a stream unit (IPMP.)
- Figure 4 presents an alternative of the case in Figure 3, with two protection points (decoding and rendered.)

The preferred embodiment described below relates, in particular, to the transmission of stream in a multimedia system, in particular an MPEG4-type system.

Recalls of the Previous Technique:

The previous technique does not allow taking into account efficient transmission (in terms of bit rate and functionality) of multimedia scenes in multicast or broadcast scenarii nor the synchronisation of
5 interdependent streams of elements linked to access control key type content.

Multimedia Representation in Broadcast and Multicast Scenarii

10 A solution is proposed in the "carousel MPEG-4" specification. Nevertheless, some functions are prohibited or become high bit rate consumption functions. In the two delivery scenarii considered, the input points to the multimedia presentation must be indicated at any
15 times. This results in the repetition of data relative to the description of the scene: BIF scene, textures, etc.

As soon as the multimedia content becomes rich, this simple repetition is unacceptable and leads to excessive downloading times. Furthermore, this specification does
20 not allow broadcasting some multimedia elements (short audio/video clips.)

Furthermore, in the unpublished request for patent EP-014600462, the data were conveyed at the transport level. In contrast, according to the invention,
25 everything is located at the so-called synchronisation layer level, which is independent from the transport level.

This provides the advantage to get rid off the various types of transport and to unify the time and

logical synchronisation data, as well as the random access markers in a single point, which allows calculating at a unique point, the decision to keep or discard the unit. This leads to further knowing more information regarding the stream, which allows specialising decisions by type of stream (of interest for video/audio with respect to BIFS, etc.)

Multimedia Synchronisation

10 The previous art in terms of multimedia synchronisation is essentially represented by the transport protocols based on RTP and by MPEG-4 (Synchronisation Layer.) In the approach used, the synchronisation mechanisms used were mainly designed to
15 time synchronise an audio stream and video stream so that they can be presented without lags. These datas were conveyed by using a time stamp system (reference clock, decoding and presentation stamps.)

20 With the advent of hierarchical encoding where the various levels of time and spatial enrichment are used to produce a presentable frame, a new synchronisation need arises. Indeed, it is necessary to synchronise the stream before decoding it (and not only at its presentation.) This constraint becomes more complex than the
25 presentation synchronisation because it is necessary to identify the units that are needed for decoding a unit in order to produce a correct frame. A single lag can lead an entire stream, as well as any streams based on the latter, to be unusable. As can be seen, this is a problem

of logical dependence between units to be decoded.

A reduced time interval is already taken into account in video MPEG-4, but it is not accessible at the system layers.

5

Data Protection

A third case of synchronisation is not considered in the previous art: that of the synchronisation of a data protection stream linked to a multimedia stream.

10

In this case, it must be ensured that any multimedia stream unit will be decrypted using a correct key before being decoded (otherwise, the results may be catastrophic.) As soon as the streams are not guaranteed to be synchronous, the synchronisation tools cannot ensure this.

15

This time, the input of the decoder and its output are synchronisation points (the decoded frame can, in turn, be encrypted.)

20

Principles of the Invention

The aims of the invention are, notably, to allow:

- the multicast and broadcast of multimedia scenes.
- the logical synchronisation of multimedia decoding.

25

This is obtained using signalling mechanisms that permit to reach these two objectives:

- A mechanism that allows configuring a stream so that each time unit making up the stream is identified in a configurable manner.

- A front chaining mechanism for broadcast scenarii.

The essential technical elements of the invention are therefore:

5 - Logical synchronisation elements between elements of several streams or within the same stream (video, audio, and data protection system.)

 - The solution allows, for each element type of the stream, indicating the element on which it depends, and the specific elements on which it depends. Several
10 implementations are possible.

The following is notably used, for any type of implementation:

- Dependency Descriptor
- Dependency Marker (optional)
- 15 - Dependency Pointer
- Marker (identifies the stream unit) (optional)

Detailed Description of at least one Embodiment Mode

20 MPEG4 Specification

Appendix 1 presents a detailed example of the implementation of the invention for MPEG-type data, in the form of an MPEG-4 specification.

25 Receiver Behaviour

The terminal receives an IOD (InitialObjectDescriptor) that references, using their descriptors (ObjectDescriptor,) at least one graphical scene object (BIFS stream: F_BIFS) and, optionally, it

references at least one graphical object description object (OD stream: F_OD.) The terminal will open these streams based on the information presented below.

Each of these object descriptors contains an elementary stream (ES) descriptor that composed it (ESDescriptor.) Each ESDescriptor contains a dependsOnESID field and an SLConfigDescriptor.

The dependsOnESID field allows constructing the graph of dependencies between streams identified by their ESID.

The SLConfigDescriptor object allows configuring the synchronisation tools.

Within the SLConfigDescriptor object, there exists the possibility of configuring the receiver so that it verifies the various dependencies in the following manner:

DependencyMarker //allows configuring the stream in order to identify its packets.

```
{
    int(5)maker Length;
}
```

DependencyDescriptor //allows describing the dependency links.

```
{
    int(2)mode;    //0: version mode by DTS
                  //1: version mode by ID
                  //2: scalable mode
                  //3: IPMP mode
                  //if mode==1 the dependency is
```

```

done % at a marker in the stream.
                                //if mode==3 the dependency is
done in an opaque manner (the IPMP system must understand
                                // the dependency and validate
5  or not the decoding/decrypting.
                                // possibly, by using a
marker. It is therefore a code
                                // that allows the protection
system to know whether it is a
10                                // decryptable unit or not
                                //if mode==0 or mode==2, the
dependency is calculated over the DTS
                                // consequently,
depLength=dtsLength in the corresponding SLConfig.
15        int(5)depLength;
        if(mode==1 || mode==0)
        {
            int(depLength)value;//value of the first
unit to search.
20        }
    }

```

Thus, a stream can be declared dependent of another stream (itself a normal media or IPMP.) In this case, it describes, in its SL configuration, how it will indicate this dependency (Dependency descriptor) using four

25 distinct modes:

DTS and ID Version Mode (modes 0 and 1):

The stream will indicate for each of these

AccessUnits (AU) a front dependency in the stream itself. In other words, the AU(n) indicates which AccessUnit will be decoded next. This signalling is done by the mean of a marker in each packet that describes either in mode 0 the
 5 DTS of the next Access Unit (unique) or the ID of the next Access Unit in mode 1.

In this case, the value of the first element to be recovered is added.

For example, this could be a BIFS stream in
 10 broadcast/multicast mode.

Scalable Mode (Mode 2):

The stream will indicate for each of these Access Units a dependency with respect to a stream on which it
 15 depends. This stream is assumed to be unique.

This principle is illustrated by Figure 1. The stream unit 11 of a dependent stream 10 normally includes a header (SLHeader) 111 and a data field (SL payload) 112. The header 111 includes, in particular, two
 20 pointers, Dep1 and Dep2, which define the dependency links 12 and 13 with stream units 141 and 142, respectively, of a base stream 14, which must be known in order to process the stream unit 11.

25 IPMP Mode (Mode 3):

The stream will indicate, for each of these AccessUnits, an identifier that allows the data protection system to decode the unit. This one given, this marker can respond whether it is able to decrypt the

unit or not.

The SLConfigDescriptor can contain one or several DependencyDescriptor and one or several DependencyMarker, which allows adjusting the various dependency cases in the stream. (A priori, a single DependencyMarker is enough, but there may be several present.)

Thus, if the SLConfig contains DependencyMarker, it will indicate a version ID for each of its packets (modes 1 and 3).

10 In the header of the SL packet corresponding to an AccessUnit, it will be found the following:

- For each dependencyMarker of the SLConfigDescriptor, a length marker (markerLength.)

- For each DependencyDescriptor, a dependencyPointer of depLength length.

Once these various markings are performed, the system can:

- a) operate in "broadcast" mode thanks to modes 0 and 1.

- b) Manage the scalability dependencies

- c) Manage the IPMP dependencies

and the combination of a), b), and c).

Operating description in IPMP mode

25 When the ObjectDescriptor of the object is received, the terminal checks the SLConfigDescriptor of each of the related streams. This will allow decoding the header of the SL packets for each of the streams; in particular, decoding the markers.

In IPMP case, there will be DTSSs and/or dependencyPointers, as illustrated in Figure 3.

For each stream AU, before it is decoded, it is processed by the IPMP system 32, by providing it with at least the following stream identifier data: ESID, DTS, dependencyPointer (IPM) 31. The IPMP system then responds (33) if it can process (decrypt) the AU by taking into account the information 311 (Code Dec) regarding the decoding. If it is not the case, and the DTS of the unit expires, the AU is destroyed (34.) Therefore, there is no attempt to decode inconsistent AUs.

In the example of Figure 4, on one hand, there are the elements of Figure 3, and on the other hand, there is a process linked to image recovery, after its decoding 41. Indeed, using field 312 (CodeComp,) the data regarding the composition, such as the addition of a tattoo or of a message on the image, can be transmitted. If the data protection system 32 does not know how to manage this composition (it does not know how to display the image (42),) for example, because the decoder does not have the required tattoo, the image is not displayed (43.)

It can also be foreseen that the frame will be marked, for example, with a logo, which disappears if the decoder has the correct key.

Operating Description in Multicast/Broadcast Mode

This operating is illustrated in Figure 2, which presents the following:

- the transmitted stream 21.
- the stream received by a first receiver (session 1) 22.

- the stream received by a first receiver (session 5 2) 23.

Session 1 starts at packet 211, then takes into account the stream unit 213, to which the stream unit 211, then the stream unit 215 points (24), according to link 25.

10 Session 2 opened a little after, starts with stream unit 212, which points (26) to stream unit 214.

According to the invention, two (or more) stream units can point to the same next stream unit. It is the merge mechanism 27: stream units 213 and 214 both point 15 to stream unit 215. Thus, although they were started at different times, the two sessions use, after a "recovery" phase, the same stream units 215. This clearly allows improving performance.

This operating is specifically described.

20 When the ObjectDescriptor is received, the terminal checks SLConfigDescriptor for each of the related streams. This allows decoding the SL packet header for each of the streams; in particular, decoding the markers.

In the case of Multicast/Broadcast, therefore, there 25 will be for the DTSSs, at least one dependencyPointer in mode 0 or 1, and a marker (mode 1 "by ID".) The terminal therefore knows which is the first unit to be recovered is for each of the streams. Therefore, it will attempt to recover the first unit corresponding to each stream.

If it receives the first unit, then it can begin to display the contents. Each unit describes in the dependencyPointer, the next unit to be received, and the DTS/marker, identifies each unit in a unique manner.

5 If the terminal does not receive the first unit (it can be aware of this by using a time out or when it receives an RAP=1 type for this stream unit that does not correspond to the desired marker). It disconnects (full closing of the session) and tries to reconnect.

10 Note that this mechanism takes into account the merger of sessions.

Also note that the mode "by ID" is required when the DTS of the next unit is not known in advance.

15 This mechanism is used in particular for BIFS, OD, Textures, audio clips, and video clips in MPEG-4. It will no longer be used for streamed audio/video.

Operating Description in Scalable Mode

20 When the ObjectDescriptor is received, the terminal checks the SLConfigDescriptor for each of the related streams. This allows decoding the SL packet header for each of the streams. For scalable video, one stream will be used as a base, and one or several other streams will depend on this stream. Each stream that depends on the

25 base stream will declare a DependencyDescriptor.

For each AU of the improvement stream, it will reference using the dependencyPointer of the AU DTS of the base stream on which it depends.

In most cases, there will be two dependencyPointer

in the improvement stream in order to point to the two reference AUs of the base video.

Operating Description in the Broadcast+IPMP Mode

5 In this case, BIFS, for example, will contain two dependencyDescriptor in the SL configuration. One for the broadcast mode, one for IPMP. It will contain a marker if the broadcast mode is by ID.

10 Application Examples:

Broadcasting an Advertisement before Starting a Program

15 In several occasions in Internet streaming, content providers systematically send an advertisement before sending the content itself. Because Internet scenarii is unicast (client-server,) this is done in phases: downloading of the advertisement, and the end of the advertisement leads to the launching of the video streaming.

20 In a multicast or broadcast scenario, where there is no recourse to a client-server operating, there is no notion of request. As such, the user normally only has access to the current status of the presentation.

25 Thanks to the front reference mechanism, this scenario becomes possible in multicast or broadcast.

 Indeed, the advertisement can be sent in a cyclical manner and the current program can be merged at the end of the advertisement.

30 This allows ensuring, for example, that all users will view the advertisement at the beginning (during this

time, the content can then be downloaded in a efficiently and incremental way.)

The same types of applications can be, for each broadcast film, a notification of the category of the film (parental guidance, less than 16 years of age, etc.)

Scalable Conditional Access

The idea here is to send the same video and audio stream (unique) that can be viewed differently depending on the rights of the user. The signalling of the video frame dependencies, with respect to the protection keys, allows decoding only the ones for which the user has the keys. All images can be decoded for the one whose got all keys - some images for the one having less privileges, etc. This allows creating conditional access in a more scalable manner (time scalability here.)

The most complex and useful scenario is one in which there are several streams and where the time scalability and resolution can be tuned.

With this frame dependency system, it is therefore possible to modulate access to media in an almost continuous manner.

Therefore, it can be imagined that some users would have keys that allow receiving sound over 5 channels (spatial sound) and others that allow only receiving stereo sound. This also allows more detailed invoicing.

MPEG-4 Interactive Television

Instead of considering that the "set-top box"

application is static, it can be considered that any of these types of applications are MPEG-4 applications that allow obtaining different channels (inline mechanism.) This MPEG-4 application would be active 24h x 24h and
5 would permit to reconfigure entirely graphical interfaces, etc.

The scene broadcasting techniques would allow efficiently downloading the graphical interface (BIFS/Textures/OD) as well as the application part (MPEG-
10 J.)

This allows a quicker deployment.

APPENDIX
EXAMPLE OF AN MPEG-4 TYPE SPECIFICATION ACCORDING TO
THE INVENTION

5 Definitions

Stream Unit (AU: Access Unit)

 A data unit that is accessible individually in an elementary stream. A stream unit (or access unit) is the
10 smallest entity to which a time data element can be attributed.

Audiovisual Object

 A representation of a natural or synthesised
15 (virtual) object that is manifested in an audio and/or visual manner. The representation corresponds to a node or group of nodes in the BIFS sequence description. Each audiovisual object is associated to zero, one, or several elementary streams that use one or several object
20 descriptors.

Audiovisual Sequence (AV Scene)

 A series of audiovisual objects with data elements that describe the scene and define their spatial or time
25 attributes, including the resulting operations of the object and user interactions.

Binary Format for Scene (BIFS)

 A coded representation of a parametric scene

description format.

Terminal

5 A system that sends or receives and presents the coded representation of an interactive audiovisual scene like the one defined by ISO/IEC 14496-1. It can be an independent system or be part of an application system compliant with ISO/IEC 14496.

10 Abbreviations and Symbols

	AU	Access Unit, or Stream Unit
	AV	Audio-visual
	BIFS	Binary Format for Scene
	CM	Composition Memory
15	CTS	Composition Time Stamp
	CU	Composition Unit
	DAI	DMIF Application Interface (see ISO/IEC 14496-6)
	DB	Decoding Buffer
20	DTS	Decoding Time Stamp
	ES	Elementary Stream
	ESI	Elementary Stream Interface
	ESID	Elementary Stream Identifier
	FAP	Facial Animation Parameters
25	FAPU	FAP Units
	NCT	Node Coding Tables
	NDT	Node Data Type
	OCI	Object Content Information
	OCR	Object Clock Reference

	OD	Object Descriptor
	ODID	Object Descriptor Identifier
	OTB	Object Time Base
	PLL	Phase Locked Loop
5	QoS	Quality of Service
	SDM	System Decoder Model
	SL	Synchronisation Layer
	SL-Packet	Synchronisation Layer Packet
	SPS	SL-Packetised Stream
10	STB	System Time Base
	TTs	Text-to-Speech
	URL	Universal Resource Locator
	VOP	Video Object Plane
	VRML	Virtual Reality Modelling Language

15

SL Packet Header Configuration

Syntax

```

class SLConfigDescriptor extends BaseDescriptor : bit (8)
20 tag=SLConfigDescrTag {
    bit (8) predefined;
    if (predefined=0= {
        bit (1) useAccessUnitStartFlag;
        bit (1) useAccessUnitEndFlag;
25 bit (1) useRandomAccessPointFlag;
        bit (1) hasRandomAccessUnitsOnlyFlag;
        bit (1) usePaddingFlag;
        bit (1) useTimeStampsFlag;
        bit (1) useIdleFlag;

```

```

    bit (1) durationFlag;
    bit (32) timeStampResolution;
    bit (32) OCRResolution;
    bit (8) timeStampLength; // must be  $\leq$  64
5    bit (8) OCRLength; // must be  $\leq$  64
    bit (8) AU_Length; // must be  $\leq$  32
    bit (8) instantBitRateLength;
    bit (4) degradationPriorityLength;
    bit (5) AU_seqNumLength: // must be  $\leq$  16
10    bit (5) packetSeqNumLength: // must be  $\leq$  16
    bit (2) extension_field_control/

    }

15    if (durationFlag) {
        bit (32) timeScale;
        bit (16) accessUnitDuration;
        bit (16) compositionUnitDuration;
    }

20    if (useTimeStampFlag) {
        bit (timeStampLength) startDecodingTimeStamp;
        bit (timeStampLength) startCompositionTimeStamp;
    }

    if (extension_field_control=0h10)
25    {
        MarkerDescriptor (0..1) markerDescriptors;
        DependencyDescriptor (0..255) dependencyDescriptors;
    }

```

```

        dependencyMarkerscount=0
        while(true)
        {
            bit(1) hasMoreMarkers;
5           if (!hasMoreMarkers) break;

            DependencyMarker
            dependencyMarkers[dependencyMarkersCount++];

10        }

        dependencyDescriptorCount =0;
        while(true)
        {
15        bit(1) hasMoreDependencyDescriptor;
            if (!hasMoreDependencyDescriptor) break;

            DependencyDescriptor dependencyDescriptor
            [dependencyDescriptor++];
20        }

    ]

```

Semantics

25 The SL packet header can be configured according to the needs of each individual elementary stream. The parameters that can be selected include the presence, resolution, and accuracy of time stamps, as well as clock references. This flexibility allows, for example, a small

increase of the SL packet header contents.

For each elementary stream, the configuration is transmitted in an SLConfigDescriptor, which is part of the ES_Descriptor associated to an object descriptor.

5 The parameters that can be configured in the SL packet header can be divided into two types: those that are applied to each SL packet (for example, OCR, sequenceNumber) and those that are only displayed in the access units (for example: time stamps, accessUnitLength,
10 instantBitrate, degradationPriority, etc.)

 The - predefined - column allows fixing the default values of a set of predefined parameters, such as those detailed below. This table can be updated by the ISO/IEC 14496 amendments to include predefined settings such as
15 those required for future profiles.

Table 1 - View of the Set of SLConfigDescriptor predefined values

Predefined value field	Description
0x00	Customers (custom)
0x01	Null SL packet header
0x02	Reserved for use in MP4 fields
0x03 - 0xFF	Reserved for ISO use

20

Table 2 - Detail of SLConfigDescriptor Predefined Values

Predefined value field	0x01	0x02
UseAccessUnitStartFlag	0	0
UseAccessUnitEndFlag	0	0
UseRandomAccessPointFlag	0	0
UsePaddingFlag	0	0
UseTimeStampFlag	0	1
UseIdleFlag	0	0
DurationFlag	0	0
TimeStampResolution	1000	-
OCRResolution	-	-
TimeStampLength	32	0
OCRLength	-	0
AU_Length	0	0
InstantBitRateLength	-	0
DegradationPriorityLength	0	0
AU_seqNumLength	0	0
PacketSeqNumLength	0	0

Predefined value field	0x01	0x02
UseAccessUnitStartFlag	0	0
UseAccessUnitEndFlag	0	0
UseRandomAccessPointFlag	0	0
UsePaddingFlag	0	0
UseTimeStampFlag	0	1
UseIdleFlag	0	0
DurationFlag	-	0
TimeStampResolution	1000	-
OCRResolution	-	-

TimeStampLength	32	0
OCRLength	-	0
AU_Length	0	0
InstantBitRateLength	-	0
DegradationPriorityLength	0	0
AU_seqNumLength	0	0
PacketSeqNumLength	0	0
TimeScale	-	-
AccessUnitDuration	-	-
CompositionUnitDuration	-	-
StartDecodingTimeStamp	-	-
StartCompositionTimeStamp	-	-

useAccessUnitStartFlag - indicates that the accessUnitStartFlag is present in each SL packet header of this elementary stream.

- 5 useAccessUnitEndFlag - indicates that the accessUnitEndFlag is present in each SL packet header of this elementary stream.

If neither useAccessUnitStartFlag nor useAccessUnitEndFlag are enabled, this means that
10 each SL packet corresponds to a complete access unit.

useRandomAccessPointFlag - indicates that the RandomAccessPointFlag is present in each SL packet header of this elementary stream.

- hasRandomAccessUnitsOnlyFlag - indicates
15 that each SL packet corresponds to a random access point.
In this case, the randomAccessPointFlag does not

need to be used.

usePaddingFlag - indicates that the paddingFlag is present in each SL packet header of this elementary stream.

5 useTimeStampFlag - indicates that the time stamps are used for synchronising this elementary stream. They are transported in the SL packet header. Otherwise, the accessUnitRate, compositionUnitRate, startDecodingTimestamp, and startCompositionTimeStamp parameters
10 transported in this SL packet header must be used for synchronisation.

The use of start and duration time stamps (useTimeStampFlag=0) is only possible under certain
15 conditions, including in an environment without errors. Random access is not easy.

useIdleFlag - indicates that the idleFlag is used in this elementary stream.

durationFlag - indicates that the constant
20 duration of the access units and the composition units for this elementary stream is subsequently indicated.

timeStampResolution - the time base resolution of the object in by-second pulses.

OCRResolution - the time base resolution of the
25 object in by-second cycles

timeStampLength - the length of the time stamp fields in the SL packet header. timeStampLength must take on the values from zero to 64 bits.

OCRLength - the length of the

objectClockReference field in the SL packet header. Several zeros indicates that no objectClockReference is present in this elementary stream. If the OCRstreamFlag is placed, OCRLength must be zero. Otherwise, OCRLength must take on the values between zero and 64 bits.

AU_Length - the length of the accessUnitLength fields in the SL packet header for this elementary stream. AU_Length must take on a value between zero and 32 bits.

instantBitrateLength - the length of the instantBitrate in the SL packet header of this elementary stream.

degradationPriorityLength - the length of the degradationPriority field in the SL packet header of this elementary stream.

AU_SeqNumLength - the length of the AU_sequenceNumber field in the SL packet header of this elementary stream.

packetSeqNumLength - the length of the packetSequenceNumber field in the SL packet header of this elementary stream.

timeScale - used to indicate the duration of the access units and composition units. A second is also divided into timeScale sections.

accessUnitDuration - the duration of a composition unit is $\text{compositionUnitDuration} * 1/\text{timeScale}$ seconds.

compositionUnitDuration - the duration of a

composition unit is compositionUnitDuration *
1/timeScale seconds.

startDecodingTimeStamp - transports the time
in which the first access unit of this elementary stream
5 must be decoded. It is transported in the resolution
specified by timeStampResolution.

extension_field_control - this field allows
extending the SL. The value 01b0 indicates that the
descriptors must be placed at the end of the
10 SLConfigDescriptor.

markerDescriptors - this table indicates a
description of markers for identifying the next access
units in the stream.

dependencyDescriptors - this table indicates
15 the dependency descriptors that specify how the previous
access units or the next units must be referenced.

MarkerDescriptor

The syntax is the following:

```
20
class MarkerDescriptor extends BaseDescriptor : bit (8)
tag=DependencyMarkerTag {
    int(5) encodedMarkerLength;
    MarkerLength= encodedMarkerLength + 1;
25 }
```

DependencyDescriptor

Syntax

```

abstract class DependencyDescriptor extends
BaseDescriptor (
);
5
class SimpleDependencyDescriptor extends BaseDescriptor :
bit (8)
tag=SimpleDependencyTag (
    bit(2) mode;
10    bit(5) dependencyLength;
    if (mode--1 __ mode==0)
    {
        bit (dependencyLength) firstvalue;
    }
15 );

class CompleteDependencyDescriptor extends BaseDescriptor
: bit (8)
tag=CompleteDependencyTag (
20    bit(2) mode;
    bit(16) ESID;
    bit(5) dependencyLength;
    if (mode==1 __ mode==0)
    {
25        int (dependencyLength) firstvalue;
    }
);

```

Semantics

Mode

There are four modes defined:

- Mode 0: reference to front by DTS
- 5 - Mode 1: reference to front by Marker
- Mode 2: back scalability reference
- Mode 3: IPMP mode

Modes 0 and 1 force each access unit to reference the next access unit.

- 10 Mode 2 forces each access unit to reference the previous access unit that is needed for decoding this access unit. (Note: In several cases, more than two dependencydescriptors are necessary for referencing two or more required access units.)

- 15 Mode 3 allows each access unit to contain an opaque identifier that can be used by the IPMP system to decide whether the decoding and composition of this access unit is possible.

- 20 Modes 1 and 3 require a MarkerDescriptor in the stream.

ESID

This optional field identifies the stream to which the DependencyDescriptor references.

- 25 For SimpleDependencyDescriptor, ESID is calculated in the following manner:

- Modes 0 and 1: the current stream
- Modes 2: depending on dependsOnESID
- Modes 3: not applicable

dependencyLength - the length of either the marker (if present) or the decodingTimeStamp.

value - the value of the first marker or the identifiers of the next access unit to decode.

5

SL Packet Header Specification

Syntax

```
aligned(8) class SL_PacketHeader (SLConfigDescriptor SL)
10 {
    if (SL.useAccessUnitStartFlag)
        bit(1) accessUnitStartFlag;
    if (SL.useAccessUnitEndFlag)
        bit(1) accessUnitEndFlag;
15    if (SL.OCRLength>0)
        bit(1) OCRflag;
    if (SL.useIdleFlag)
        bit(1) idleFlag;
    if (SL.usePaddingFlag)
20    bit(1) paddingFlag;
    if (paddingFlag)
        bit(3) paddingBits;
    if (!idleFlag && (!paddingFlag __ paddingBits!=0)) {
        if (SL.packetSeqNumLength>0)
25        bit ( S L . p a c k e t S e q N u m L e n g t h )
        packetSequenceNumber;
        if (SL.degradationPriorityLength>0)
            bit(1) DegPrioflag;
        if (DegPrioflag)
```

```

        bit(SL.degradationPriorityLength)
    degradationPriority;
    if (OCRflag)
        bit(SL.OCRLength) objectClockReference;
5
    if (accessUnitStartFlag) {
        if (SL.useRandomAccessPointFlag)
            bit(1) randomAccessPointFlag;
        if (SL.AUseqNumLength > 0)
10        bit(SL.AU_seqNumLength) AU_sequenceNumber;
        if (SL.useTimeStampsFlag) {
            bit(1) decodingTimeStampsFlag;
            bit(1) compositionTimeStampFlag;
        }
15        if (SL.instantBitrateLength > 0)
            bit(1) instantBitrateFlag;
        if (decodingTimeStampFlag)
            bit(SL.timeStampLength) decodingTimeStamp;
        if (compositionTimeStampFlag)
20        bit(SL.timeStampLength) compositionTimeStamp;
        if (SL.AU_Length > 0)
            bit (SL.AU_Length) accessUnitLength;
        if (instantBitrateFlag)
            bit (SL.instantBitrateLength) instantBitrate;
25    }
    }
    if (SL.hasMarker && beginningOfAU())
    {
        for (int I=0, I< markerDescriptorcount; I++)

```

```

        (
            bit(marker.length) markervalue
        )
    )
5   for (int I=0; I< dependencyDescriptorCount;I++)
    [
        if (dependencyDescriptor.mode>>1 ==0)
        (
            bit      (dependencyDescriptor[I].depLength)
10   dependencyPointerValue;
        )
    ]
}

```

15 Semantics

accessUnitStartFlag - when equal to one, it indicates that the first byte of the load for this SL packet is the start of a unit access. If this syntax element is omitted from the configuration of the SL packet header, its default value is known from the previous SL packet according to the following rule:

accessUnitStartFlag = (the SL packet before accessUnitEndFlag=1)?1:0.

accessUnitEndFlag - when equal to one, it indicates that the last byte of the load for this SL packet is the last byte of the current access unit. If this syntax element is omitted from the configuration of the SL packet header, its default value is only known after receipt of the SL packet, according to the

following rule:

accessUnitEndFlag = (the SL packet after
accessUnitStartFlag==1)?1:0

If neither AccessUnitStartFlag nor
5 AccessUnitEndFlag are configured in the SL packet
header, it means that each SL packet corresponds to a
single access unit, in which each
accessUnitStartFlag = accessUnitEndFlag = 1.

Note that, when the SL packet header is
10 configured to use accessUnitStartFlag but not
accessUnitEndFlag nor accessUnitLength, there is
no guarantee that the terminal will be able to determine
the end of an access unit before the next one is
received.

15 OCRflag - when equal to one, it indicates that an
objectClockReference will follow. The default value
for OCRflag is zero.

idleFlag - indicates that this elementary stream
will be inactive (that is, absent of desired data) for an
20 undetermined amount of time. This sign can be used by the
decoder to distinguish between a deliberate absence and
an absence due to an error in the subsequent SL packets.

paddingFlag - indicates the data completion mode
to be used in this SL packet. The default value for
25 paddingFlag is zero.

paddingBits - indicates the data completion mode
to be used in this SL packet. The default value for
paddingBits is zero.

If paddingFlag is placed and paddingBits is

equal to zero, this indicates that the subsequent load of this SL packet consists only of completion bytes. accessUnitStartFlag, randomAccessPointFlag and OCRflag must not be placed if paddingFlag is placed
 5 and paddingBits is zero.

If paddingFlag is placed and paddingBits is greater than zero, this indicates that the load of this SL packet is followed by. paddingBits, formed of zero bits for aligning the bytes of the load.

10 packetSequenceNumber - if present, it must be continuously increased for each SL packet as a module counter. A discontinuity in the decoder corresponds to one or several missing SL packets. In this case, an error must be indicated at to the synchronisation layer. If
 15 this syntax element is omitted from the configuration of the SL packet header, the control of the continuity of the stream units by the synchronisation layer cannot be done for this elementary stream.

SL Packet Duplication: the elementary streams that
 20 have a sequenceNumber field in their SL packet headers must use the duplication of SL packets for error recovery. The duplicated SL packet(s) must immediately follow the original. The packetSequenceNumber of duplicated SL packets must have the same value and each
 25 byte of the original SL packet must be duplicated, with the exception of an objectClockReference field, if present, which must encode the valid value for the duplicated SL packet.

degPrioFlag - when equal to one, it indicates

that degradationPriority is present in this packet.

degradationPriority - indicates the importance of the load of this SL packet. The streamPriority defines the base priority of an ES.
 5 degradationPriority defines a priority decrease for this SL packet with respect to the base priority. The priority for this SL packet is given by:

$$\text{SL_PacketPriority} = \text{streamPriority} - \text{degradationPriority}$$

10 degradationPriority maintains this value until the next occurrence. This indication can be used by the elementary stream decoder as well as the adapter for an instance of a specific distribution layer. The proportion of degradation among the SL packets of the various
 15 elementary streams increases as the SL_PacketPriority decreases.

objectClockReference - contains an object time stamp. The OTR t time value is reconstructed from this OCR time stamp according to the following formula:

20
$$t = (\text{objectClockReference} / \text{SL.OCRResolution}) + K * (2^{\text{SL.OCRLength}} / \text{SL.OCRResolution})$$

where k is the time that the objectClockReference counter has covered.

25 objectClockReference is only present in the SL packet header if OCRflag is placed.

Only one OCR value can be transported without loading the inside of the SL packet.

Described below are the semantics of the syntax

elements that are only present at the beginning of an access unit when indicated specifically by `accessUnitStartFlag` in the binary stream:

`randomAccessPointFlag` - when equal to one, it
5 indicates that the random access to the contents of this elementary stream is possible. `randomAccessPointsFlag` must only be placed if `accessUnitStartFlag` is placed. If this syntax element is omitted from the configuration of the SL
10 packet header, its default value is the `SLConfigDescriptor.hasRandomAccessUnitOnlyFlag` value for this elementary stream.

`AU_sequenceNumber` - if present, it must be continually increased for each access unit as a module
15 counter. A discontinuity at the decoder corresponds to one or several missing access units. In this case, the error must be indicated to the user of the synchronisation layer. If this syntax element is omitted from the configuration of the SL packet header, the
20 control of the continuity of the stream units by the synchronisation layer cannot be executed for this elementary stream.

 Duplication of access units: the access units sent using the same number of sequences than the AU
25 immediately before must be ignored. Such a duplicate access unit, whose original does not have RAP placed, but the duplicate units does, allows adding random access points to the transmitted stream. This allows clients to enter into the stream at defined points, during its

transmission, while other clients already receive the stream.

decodingTimeStampFlag - indicates that a decoding time stamp is present in this packet.

5 compositionTimeStampFlag - indicates that a time stamp composition is present in this packet.

accessUnitLengthFlag - indicates that the length of this access unit is present in this packet.

instantBitrateFlag - indicates that an
10 instantBitrate is present in this packet.

decodingTimeStamp - a decoding time stamp, such as that configured in the related SLConfigDescriptor. The decoding time td of this access unit is reconstructed from this time decoding
15 stamp according to the following formula:

$$td = (\text{decodingTimeStamp} / \text{SL.timeStampResolution} + K * 2^{\text{SL.timeStampLength}} / \text{SL.timeStampResolution})$$

where k is the time that the decodingTimeStamp
20 counter has covered.

A decodingTimeStamp must only be present if the decoder time is different from the time composition for this access unit.

compositionTimeStamp - a time stamp
25 composition such as that configured in the related SLConfigDescriptor. The time composition tc of the first composition unit results from the fact that this access unit is reconstructed from the time stamp composition according to the following formula:

$$td = (compositionTimestamp /$$

$$SL.timeStampResolution + k * 2^{SL.timeStampLength} /$$

$$SL.timeStampResolution$$

where k is the time that the compositionTimeStamp
 5 counter has covered.

accessUnitLength - the length of the access unit
 in bytes. If this syntax element is not present or has a
 value of zero, the length of the access unit is unknown.

instantBitrate - the instantaneous bit rate in
 10 bits per second of this elementary stream until the next
 instantBitrate field is found.

markerValue - the value of a marker that allows
 identifying the access unit. This marker is defined if
 markerDescriptor exists.

15 DependencyPointerValue - a DTS or marker index
 as defined by the DependencyDescriptor.

MarkerDescriptorCount: the number of marker
 descriptors.

20 DependencyDescriptorCount: the number of
 dependent descriptors.

Decoding Semantics

Front Reference Mechanism (Modes 0 and 1)

25 The SLConfigDescriptor related to an ES
 indicates the first access unit that allows entering into
 the stream.

If the reference mode is DTS, then the
 SLConfigDescriptor must contain a decodingTimeStamp.

Otherwise, a marker is used to mark each access unit. 0 and -1 have a special significance:

//0 means that no more access units will follow

//-1 means that any access unit can be used.

- 5 Each access unit must contain a marker and a dependencypointer that allows each access unit to indicate the next access unit.

Rear Reference Mechanism (Mode 2)

- 10 The SLConfigDescriptor will define n DependencyDescriptor type descriptors that will indicate the access units in the ES that ESID references.

- Each access unit of the current stream will point the access units over the ES whose identifier is ESID, called ES_base, using the DependencyPointers as reference
 15 to the ES_base access units (identified by ESID) through their DTS.

IPMP Mode (Mode 3)

- 20 The DependencyPointers are transmitted to the IPMP system before decoding. This opaque pointers allow the IPMP resources to decide whether it is possible or not to decode the access unit. It can respond in the negative if the keys have not been received or if the rights do not
 25 allow it. This dependency pointer is linked to the composition unit after decoding.

It is returned to the IPMP system before composition, the IPMP resources will then decide if the unit can be present or not.

Clock Reference Stream

A streamType = ClockReferenceStream elementary stream must be declared using the objector descriptor. It is used for transporting the object clock reference time stamps. Multiple elementary streams in a name set can reference such a ClockReferenceStream using the OCR_ES_ID syntax element in the SLConfigDescriptor to prevent the repeated transmission of the clock reference information. Nevertheless, it should be noted that circular references between elementary streams using OCR_ES_ID are not allowed.

On the synchronisation layer, a ClockReferenceStream is performed by configuring the syntax of the SL packet header for the packaged stream at the SL level so that only the required OCR values of the OCRResolution and OCRLength are present in the SL packet header.

There is no SL packet charge present in a packaged stream-SL of streamType = ClockReferenceStream

In the DecoderConfigDescriptor for a clock reference stream, ObjectTypeIndication must be placed on '0xFF', hasRandomAccessUnitsOnlyFlag over one and bufferSizeDB over '0'.

Indicated below are the recommended values for the SLConfigDescriptor of a clock reference stream:

Table 3 - SLConfigDescriptor Values of the
SLConfigDescriptor Parameters of a ClockReferenceStream

useAccessUnitStartFlag	0
useAccessUnitEndFlag	0
useRandomAccessPointFlag	0
usePaddingFlag	0
useTimeStampsFlag	0
useIdleFlag	0
useIdleFlag	0
durationFlag	0
timeStampResolution	0
timeStampLength	0
AU_length	0
degradationPriorityLength	0
AU_seqNumLength	0

Restrictions for Elementary Streams that Share the same Time Base Object

When a time base object can be shared between several elementary streams through OCR_ES_ID, a number of restrictions for accessing these elementary streams and their processing exist, as follows:

When several elementary streams share a simple time base object, the elementary streams without integrated clock reference information must not be used by the terminal, even if they are accessible, until the elementary stream transporting the object clock reference information becomes accessible.

If an elementary stream without integrated clock reference becomes available to the terminal after the elementary stream that transports the object clock reference information, it must be delivered in synchronisation with the other stream(s.) Note that this implies that such a stream must not be delivered from the

beginning, depending on the current value of the time base object.

When an elementary stream transporting object clock reference information becomes unavailable or is used elsewhere (for example, in standby mode,) all the other elementary streams that use the same time base object must follow this approach; that is, they must become unavailable or be manipulated in the same direction.

When an elementary stream without integrated object clock reference information becomes unavailable, this does not affect the other elementary streams that share the time base object.

Using the Configuration Options for Clock References and Time Stamp Values

Resolving the Ambiguity in the Recovery of a Time Base Object

Depending on the limited length of the objectClockReference values, these time stamps can be ambiguous. The OTB time value can be reconstructed each time that an objectClockReference is transmitted in the SL packet headers, according to the following formula:

$$t_{\text{OTB_reconstructed}} = (\text{objectClockReference} / \text{SL.OCRResolution}) + k * (2^{\text{SL.OCRLength}} / \text{SL.OCRResolution})$$

where k is a whole value indicating the number of loops. The resulting time base $t_{\text{OTB_reconstructed}}$ is measured in

seconds.

When the first objectClockReference for an elementary stream is acknowledged, the k value must be set to one. For each subsequent occurrence of objectClockReference, the k value is estimated as follows:

The terminal must understand the resources for estimating the value of the time base object at each instant.

Each time that an objectClockReference is received, the estimated current value of OTB $t_{OTB_estimated}$ must be sampled. Therefore, $t_{OTB_res}(K)$ is evaluated for different values for k. The k value that minimises the duration $_t_{OTB_estimated} - t_{OTB_rec}(k)_$ must be considered as the correct value for $t_{OTB_reconstructed}$. This value must be used as a new contribution to the time base object estimation mechanism.

The application must ensure that this procedure produces a non ambiguous value for k by selecting an appropriate length and resolution for the objectClockReference element and a sufficiently high frequency of objectClockReference insertion values in the elementary stream. The choice for this value depends on the delivery jitter for the SL packets, as well as the maximum expected lag between the clocks of the terminal and the receiver.

Resolving the Ambiguity in the Recovery of the Time Stamp

Depending on the limited length of the

decodingTimeStamp and compositionTimeStamp values, these time stamps can become ambiguous, as indicated by the following formula:

$$T_{ts}(m) = (\text{TimeStamp} / \text{SL.timeStampResolution}) + m * (2^{\text{SL.timeStampLength}} / \text{SL.timeStampResolution})$$

where TimeStamp is either a decodingTimeStamp or a compositionTimeStamp and m is the whole value that indicates the number of loops.

The correct $t_{\text{timestamp}}$ value of the time stamp can be estimated as follows:

Each time that a TimeStamp is received, the current estimated value of OTB $t_{\text{OTB_estimated}}$ must be sampled. $t_{ts}(m)$ is evaluated for the various values for m. The m value that minimises the term $|t_{\text{OTB_estimated}} - t_{ts}(m)|$ is considered as the correct value for $t_{\text{timestamp}}$.

The application can choose, independently for each individual elementary stream, the length and resolution of the time stamps, in order to meet the requirements regarding the non ambiguous positioning of time events. This choice depends on the maximum time during which an SL packet with a TimeStamp can be sent, after the moment indicated by the TimeStamp, as well as the requested accuracy of the time positioning.

25 Remarks regarding the Use of Object Clock References and Time Stamps

The time line of an object base time allows distinguishing two separate instants by more than the $/\text{SL.OCRResolution}$. OCRResolution must be chosen

with a sufficiently large size to allow obtaining the accuracy required by the application for synchronising a set of elementary streams.

The time and composition stamps allow distinguishing
5 two individual instants separated by more than the
/SL.timeStampResolution. timeStampResolution
must be chosen with a size sufficiently large to allow
obtaining the accuracy required by the application in
terms of obtaining the access units for a given
10 elementary stream.

A TimeStampResolution that is greater than the
OCRResolution will not allow obtaining the best
discrimination between events. If
TimeStampResolution is less than OCRResolution,
15 the events for this specific stream cannot be obtained
with the maximum accuracy possible with this given
OCRResolution.

The OCRLength parameter is indicated in the
configuration of the SL header.
20 $2^{SL.OCRLength}/SL.OCRResolution$ is the time interval
covered by the objectClockReference counter before
it loops. A sufficiently high OCRLength must be chosen
in order to meet the needs of the application for a non
ambiguous positioning of time events for all elementary
25 streams.

When the application knows the k value defined
above, the OTB time line is clear for each time value.
When the application cannot reconstruct the k factor, for
example, in the case of an application that allows random

access without additional information, the OTB time line is made ambiguous for mode $2^{SL.OCRLength}/SL.OCRResolution$. Thus, each time stamp referring to this OTB is ambiguous. Nevertheless, it can
 5 be considered clear within an application environment using the knowledge that the supposed maximum jitter and constraints on the duration in which an access unit can be sent before it is decoded.

It should be noted that the elementary streams that
 10 choose a time interval $2^{SL.timeStampLength} / SL.timeStampResolution$ greater than $2^{SL.OCRLength} / SL.OCRResolution$ can only obtain, in an unambiguous manner, the time events in the smallest of the two time intervals.

15 In some cases, when k and m cannot be correctly estimated, the buffer model can be transgressed, which leads to unexpected operations and results by the decoder.

For example, in considering an application that
 20 wishes to synchronise the elementary streams with an accuracy of 1 ms, $OCRResolution$ must be chosen as equal or greater than 1000 (the time between two consecutive OCT pulses is therefore equal to 1ms.) It can be assumed that $OCRResolution=2000$.

25 The application supposes a jitter between the STB and the OTB of 0.1% (that is, 1ms per second.) The clocks must therefore be adjusted at least every second (that is, in the worst case scenario, that the clocks deviate 1 ms, which is the accuracy constraint.) It can be supposed

that the objectclockReference are sent every 1s.

The application may want to have a clear OTB time line of 24h without needing to reconstruct the factor k. The OCRLength is therefore chosen as a result, as with
 5 $2^{SL.OCRLength/SL.OCRResolution}=24h.$)

Suppose now that the application wishes to synchronise the events inside an elementary stream, except with an accuracy of 10 ms. TimeStampResolution must be chosen as equal to or
 10 greater than 100 (the time between two consecutive pulses of TimeStamp is therefore equal to 10 ms). Suppose that TimeStampResolution=200.

The application wishes the capacity to send access units at a maximum of one minute before their decoder or
 15 composition times. The timeStampLength is therefore chosen as

$2^{SL} \quad \text{timeStampLength}/SL.\text{timeStampResolution}=2$
 minutes.